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HATCH--A Model for Fish Hatchery Analysis

Dr. Frederick C. Johnson

Applied Mathematics Division
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National Bureau of Standards
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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

Preface

The HATCH model is an automated system for analyzing the physical, biological and economic factors of fish hatchery operation and for computing optimal hatchery management policies. This project was sponsored by the Washington State Department of Fisheries, Olympia, Washington under Service Contract No. 548.

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I. Introduction

The HATCH model for fish hatchery analysis provides hatchery operators with a management tool for analyzing the biological, physical and economic factors of hatchery operation. The model performs a benefit:cost analysis of hatchery production by computing the major costs associated with a hatchery production policy and the economic contribution to the fisheries of the fish produced. The model can be used as a simulation tool to evaluate current hatchery procedures and to compare the benefits derived from alternative management policies developed by the hatchery operator. An important new capability has been added to HATCH which enables the model to automatically compute a management policy which <u>maximizes</u> the benefit:cost ratio of a hatchery. With this option, the model will determine the species mix, the number of fish released and the size and time of the releases which produce the maximum dollar contribution to the fisheries per dollar of feed cost. The use of this feature greatly reduces the amount of work required to program a hatchery, especially a hatchery for which the effects of variations in size and time of release are known or postulated.

The basic concepts and procedures of the HATCH model have been documented in a previous report [1]. Since one of the tasks of the current contract was to produce a User's Guide to the HATCH model, much of that material is included in this report

for sake of completeness. Sections II-IV of this report, together with the Appendices provide a User's Guide to the HATCH model. This report also covers the extensions made to the model during the performance of this contract. These extensions are covered in Section II. 4 and Section IV. Section V considers applications of the HATCH model or the techniques used in the model to areas of hatchery operation other than production planning.

II. The HATCH Model

Salmon hatchery management encompasses a wide array of physical, biological and economic factors. Many of these factors (e.g., species mix, feed rates and pond management) can be directly controlled by the hatchery operator. However, certain critical factors such as source water temperature, flow rates and pond sizes either cannot be controlled or require expensive special equipment. The challenge of successful hatchery operation is to achieve a maximum economic contribution to the fisheries through appropriate adjustment of the controllable parameters of hatchery operation.

A large body of knowledge of good practical hatchery procedures has been built up over the years. Consequently, a substantial degree of latitutde exists in the determination of feed rates, size and time of release, and other important variables in the hatchery production environment. The importance of this flexibility is demonstrated by experimental work performed by the Washington State Department of Fisheries (see Hager [2]) which showed that variations in size and time of release have a major impact on adult hatchery returns. Recent, as yet unpublished, data obtained by this agency for delayed release Coho salmon has verified that the size and time of release of hatchery fish also has a major impact on fishery contribution. In short, hatchery policy not only affects the quality of the fish produced, but these decisions can also have a

substantial economic leverage on the fisheries.

The degree of management flexibility within a hatchery coupled with the impact of hatchery operating policy on fishery performance provides a key rationale for the development of improved techniques for hatchery analysis. The HATCH model has been developed to meet this need by providing an effective analytic tool for evaluating hatchery management policy based on fishery contribution information.

II. 1. An Overview of HATCH

The basic concept of the HATCH model is to use a computer implementation of a combination of mathematical equations, tables and logic to emulate the principal processes of hatchery operation. The input to the model describes the physical parameters of a hatchery, the biological characteristics of each brood stock, the operational policies governing fish releases, the fishery performance of hatchery produced fish and the major hatchery investment costs and operating costs. The output from the model consists of a semi-monthly status summary for each brood of fish reared in the hatchery, a plot of water allocation in the hatchery throughout the year, a pollution analysis of hatchery effluent, an analysis of projected fishery benefits for each brood of fish and a benefit: cost analysis of the hatchery operating policy.

The HATCH model is primarily a time oriented model in which the sequence of events within the model is the same as in an actual hatchery. However, the model has been specifically designed to perform certain computations out of time sequence in order to achieve a greater flexibility in hatchery analysis, and in this case the model acts as functionally oriented model. This distinction is not apparent to the user of the model.

The time frame of the model is a half-month, and the calendar year is divided into 24 equal half-month time periods of slightly over 15 days each (adding up to a 365 day year). All hatchery events such as initial ponding of fish, pond splitting and releasing of fish are constrained by HATCH to occur at the beginning of a time period. The semi-monthly time frame provides a satisfactory compromise between computational load and flexibility of event timing.

The fish reared in a hatchery are divided into lots for analysis by the HATCH model. A lot of fish is any group of fish that is distinguished in the hatchery for any reason. A lot may be a species (Coho), a race (Elwha Chinook) or simply a group of experimental fish, and separate biological parameters and management policies are associated with each lot.

The HATCH program consists of two models, a hatchery simulation model and a fishery performance model, and an optimizer

module which can be used to determine the most cost effective hatchery management policy. A diagram of the major task sequence of HATCH is given in Figure II.1. The out of sequence computation of fish growth occurs because this information is required by the optimizer and for the egg computations when the optimizer is not used (see Section II.3.).

The computational sequence of the hatchery simulation model varies slightly between simulation and hatchery optimization runs. This is due to the difference in the treatment of lot priorities in these two cases. One of the principal functions of the hatchery model is the allocation of available water and pond space to the lots of fish in the hatchery. Since these resources are limited, the allocation of water and pond space is performed on a priority basis, and each lot of fish is assigned a priority by the input data. During a simulation run (no optimization is performed) all of the water and pond requirements of the highest priority lot are resolved first, and any unused water and pond space is made available to the next priority lot. This procedure continues until all lots are processed.

The treatment of lot priorities changes when the hatchery optimization option is selected. In this case, the assigned lot priorities are ignored for water allocation purposes

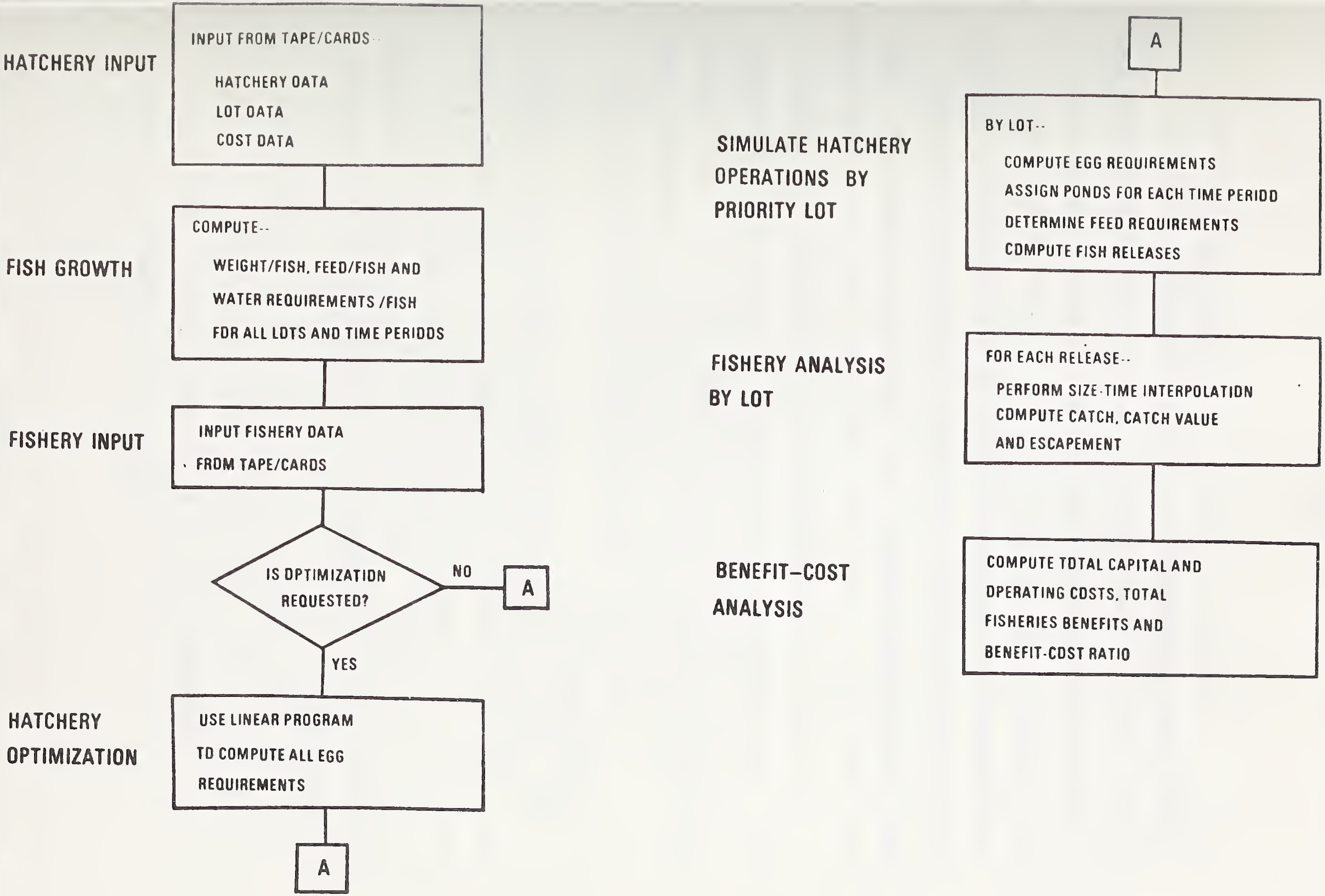

Figure II.1. HATCH Model Task Sequence

because the optimizer allocates water to the various lots in a manner that maximizes the economic contribution of the hatchery produced fish. This process is completely independent of the user assigned lot priorities, and it may happen that a high priority lot receives no water at all (no fish are reared) because some combination of the remaining lots produces greater fishery benefits. However, the optimizer deals only with water allocation and not with pond space allocation. The reason for this is that fish in different lots are not permitted to share ponds, and the problem of simultaneously optimizing water usage and pond space allocation is a difficult mathematical problem for which no good solution techniques are available. After water allocation has been resolved by the optimizer, pond space is allocated on a priority basis in the same manner as in the simulation case.

After all of the lots have been processed by the hatchery model, the fishery model is used to calculate the fishery contributions of the hatchery production, and a benefit:cost analysis is performed. The details of the principal operations of HATCH as shown in Figure II.1. are covered in the remainder of this chapter.

II. 2. Fish Growth

The growth equations used in HATCH were developed by Stauffer [3] and are based on the pioneering work of Brett [4]. The purpose of these equations is to relate the initial weight of a fish at the beginning of a time period, the pond water temperature and the feed ration to the incremental growth achieved during the period. A detailed description of the biological aspects of the Stauffer equations is given in [3].

We introduce the following notation:

t_i -- the beginning of time period i,

T -- pond water temperature during time period i,

W_i -- the dry weight of a fish at t_i,

G -- daily specific growth rate,

R -- daily ration (in fraction of body weight),

R_x -- the maximum ration which can be fed,

R_m -- the maintenance ration,

G_x -- the maximum growth rate.

The terms maximum ration and maintenance ration follow Brett [4]. The maximum ration is the ration which gives the maximum growth rate G_x, and any ration greater than R_x does not increase the fish growth rate. The maintenance ration gives a zero growth rate, and any ration less than R_m would result in a loss of body weight.

The growth model is based on the exponential growth equation

$$W_{i+1} = W_i e^{G(t_{i+1} - t_i)} \tag{1}$$

and Stauffer's equations,

$$G = G_x \sin\left(\frac{\pi}{2} \frac{R - R_m}{R_x - R_m}\right) , \tag{2}$$

$$G_x = \left(\sum_{i=1}^{5} \alpha_i T^{i-1}\right) \alpha_6 W_i^{-\alpha_7} , \tag{3}$$

$$R_m = \left(\lambda_1 10^{\lambda_2 T}\right) \lambda_3 W_i^{-\lambda_4} , \tag{4}$$

$$R_x = \left(\lambda_5 + \lambda_6 \ln T\right) \lambda_7 W_i^{-\lambda_8} . \tag{5}$$

Equation (2) relates the specific growth rate G to the maximum ration, the maintenance ration and the maximum growth rate. Equations (3) - (5) give G_x, R_m and R_x in terms of the pond water temperature, initial body weight and the parameters $\alpha_1, \alpha_2, \ldots, \alpha_7, \lambda_1, \lambda_2, \ldots, \lambda_8$. The α and λ parameters are part of the input to HATCH. Stauffer derived the following values, but others may be used as desired:

$$\alpha_1 = -15.949$$

$$\alpha_2 = 1.3849$$

$$\alpha_3 = -.046018$$

$$\alpha_4 = .00069698$$

$$\alpha_5 = -.0000038991$$

$$\alpha_6 = .0383$$

$$\alpha_7 = .3333$$

$$\lambda_1 = .0397$$

$$\lambda_2 = .0280$$

$$\lambda_3 = .0321$$

$$\lambda_4 = .2165$$

$$\lambda_5 = -8.82$$

$$\lambda_6 = 2.51$$

$$\lambda_7 = .171$$

$$\lambda_8 = .3333$$

In addition to initial weight, pond temperature, ration and the α and λ parameters, the Stauffer equations also take into account the moisture content of feed and fish flesh since W_i is dry weight and R refers to dry weight of the feed. Both of these moisture content parameters are input variables to HATCH. The moisture content of fish flesh is an optional variable, however, and a default value of .75 is used by the program.

In HATCH, the growth of each lot of fish is modelled from the time of ponding to final release from the hatchery. The initial weight of the fish at ponding time is specified, and subsequent growth is determined by the user by one of two alternate methods -- by ration schedule or by weight schedule. In the first method, the user specifies the daily ration for the fish for each month the fish are in ponds. Growth is then computed using equations (1) - (5), and the weight of the fish at the beginning of each time period is obtained.

The weight schedule method of specifying growth operates in the reverse fashion, i.e., the user specifies the weight/fish for each month the fish are in ponds, and HATCH computes monthly rations. This is accomplished by solving equations (1) and (2) for G and R, respectively:

$$G = \frac{\ln(W_{i+1}/W_i)}{t_{i+1} - t_i} , \tag{6}$$

$$R = R_m + \frac{2}{\pi} (R_x - R_m) \sin^{-1} (G/G_x) . \tag{7}$$

Thus, equations (6) and (7) together with (3) - (5) give the daily ration as a function of the weight schedule.

It may happen that the user has specified a growth

schedule which cannot be achieved because of the constraints imposed by G_x and R_x. HATCH automatically tests for this possibility, and if it occurs the new weight or ration is computed based on R_x and G_x. The output is also annotated to inform the user of this modification.

While the weight and ration computations are carried out, the water requirements of the fish for each time period are also computed. These requirements are given in terms of gallons per minute inflow per fish (GPM/fish). The water requirements are dependent upon the weight of the fish and the temperature of the pond water. The data required for these computations are furnished by the user in the form of a table which gives the pounds of fish per GPM that a pond can hold as a function of weight and temperature. The HATCH model uses two-dimensional linear interpolation to obtain the water requirements.

II. 3. Egg Computations

One of the more useful features of the HATCH model is the ability to automatically compute the number of eggs that must be taken to achieve a specified production goal. This can be done because the sequence of events in HATCH has been structured so that a complete knowledge of planned releases, pond mortalities, and water requirements per fish is available prior to the

actual egg computation. In fact, the process of hatchery optimization uses the same information and can be viewed as a type of egg computation. However, this will be covered in the following section. In this section we are concerned with the pure simulation case in which the releases have been specified by the user.

The egg computations are based on a set of equations which relate all factors affecting hatchery capacity to the initial egg requirements. We must again introduce some notation:

N_i -- the number of fish in the lot at the beginning of time period i,

S_i -- the survival rate for time period i,

D_i -- the number of fish released at the beginning of time period i,

B_i -- D_i/N_i ,

R_i -- $1 - B_i$ (R_iN_i is the number of fish remaining after a release),

F_i -- the water flow available during time period i in GPM,

C_i -- the GPM/fish water requirements for the lot during time period i.

It follows from the definitions that the number of fish alive at the beginning of time period $i + 1$ is

$$N_{i+1} = Q_iN_i \tag{8}$$

where $Q_i = S_i R_i$. For simplicity, we assume that the fish are ponded in the first time period. Then N_1 is the initial number of ponded fish and

$$N_2 = Q_1 N_1$$

$$N_3 = Q_2 N_2 = Q_2 Q_1 N_1$$

$$\vdots$$

$$N_n = Q_{n-1} \, Q_{n-2} \cdots Q_{n-1} \, N_1 \, .$$

Let $T_i = \prod_{j=1}^{i} Q_i$. We then have

$$N_i = T_i N_1 \, , \qquad i = 2, 3, \ldots \, . \tag{9}$$

Equation (9) relates the number of fish alive at the beginning of time period i to the initial number of ponded fish. The survival rates S_i and the release fractions B_i form part of the HATCH input.

The next step is to relate the number of fish to the available water flow for each time period. The water requirements of the fish in time period i are $C_i N_i$, and these requirements must not exceed the available water F_i. Thus, we have the constraint inequalities

$$C_i N_i \leq F_i \, , \qquad i = 1, 2, \ldots, n \, , \tag{10}$$

where n is the final time period the fish are in the hatchery. Substituting for N_i in (10), we obtain

$$C_i T_i N_1 \leq F_i$$

or

$$N_1 \leq F_i / C_i T_i , \qquad i = 1, 2, \ldots, n. \tag{11}$$

Equation (11) states that the <u>initial</u> number of ponded fish must satisfy n inequalities (one generated by each time period) in order not to exceed the available water. Let $\bar{F}_i = F_i / T_i C_i$ and define

$$\bar{F}_M = \min_{1 \leq i \leq n} \{\bar{F}_i\} . \tag{12}$$

That is, $\bar{F}_M$ is the minimum of the n quantities $\bar{F}_1, \bar{F}_2, \ldots, \bar{F}_n$. If we set $N_1 = \bar{F}_M$, then there will be sufficient water in the hatchery for the fish in all time periods, and the total available water will be used in time period M.

The number of eggs E is then given by

$$E = N_1 / (S_F \cdot S_E)$$

where S_F is the fry survival rate and S_E is the egg survival rate.

In the above derivation it was tacitly assumed that $n \leq 24$ (recall that HATCH partitions the year into 24 time periods),

or, in other words, that the fish resided in the hatchery for one calendar year or less. The egg computations must be slightly modified for fish such as Coho salmon which reside in a hatchery longer than one year because of the overlap that occurs between two successive brood years. The required modification is readily obtained if the overlap problem is viewed not as two successive brood years but rather as a single brood year overlayed on top of itself in a "wraparound" fashion.

For the time periods in which the overlap occurs equation (10) is replaced by

$$C_iN_i + C_{i+24} N_{i+24} \leq F_i , \qquad (13)$$

where the first term gives the water requirements for age 0 fish, and the second term gives the requirements for age 1 fish of the same lot exactly one year later. Substituting for N_i and N_{i+24} in (13), we obtain

$$C_iT_iN_1 + C_{i+24} T_{i+24} N_1 \leq F_i ,$$

or

$$N_1 \leq F_i/(C_iT_i + C_{i+24} T_{i+24}) . \qquad (14)$$

Thus, the analysis is identical except for the modification for the overlap time periods. It is important to note that the above analysis for a 2-year fish such as Coho not only fills the hatchery to capacity for any specified combination of releases

but also determines the exact ratio between age 0 fish and age 1 fish that is necessary to achieve full capacity.

One final remark should be made about the preceeding egg computations. The equations relate eggs to available water, and in most circumstances this is sufficient. However, it may occur that it is not possible to use all of the available water because of insufficient pond space resulting from pond conflicts among the lots. In this case, HATCH will automatically cut the number of fish back to available pond capacity by means of an unplanned fish release.

II. 4. Lot and Hatchery Optimization

The egg computation equations derived in the preceeding section assumed that the release fractions B_i were known. With a slight rearrangement, the same basic equations provide the basis for a formulation of the egg computations in which both the initial egg requirements and the optimal release fractions can be obtained. We shall consider two cases: lot optimization and hatchery optimization. Both options exist in the HATCH model.

The term lot optimization is used for the determination of a set of releases which maximize the fishery contributions of a lot relative to the feed expense of the lot. The major difference in the following development from that of Section II.3 is in the treatment of the time sequence. In Section II.3 we

worked forward in time, now we shall work backward in time beginning with the final release D_n. Following the same notation as in Section II. 4. we have that

$$N_{i+1} = S_i(N_i - D_i) \ . \tag{15}$$

Equation (15) is merely a restatement of (8) and relates the number of fish alive at t_{i+1} to the number alive at t_i, the number released at t_i and the survival rate S_i. Solving (15) for N_i (the reverse time process) we obtain

$$N_i = K_i \, N_{i+1} + D_i \ , \tag{16}$$

where $K_i = 1/S_i$. Starting with D_n and proceeding backwards, we have

$$\begin{aligned}
N_n &= D_n \\
N_{n-1} &= K_{n-1} \, N_n + D_{n-1} \\
&= K_{n-1} \, D_n + D_{n-1} \\
N_{n-2} &= K_{n-2} \, N_{n-2} + D_{n-2} \\
&= K_{n-2} \, K_{n-1} \, D_n + K_{n-2} \, D_{n-1} + D_{n-2}
\end{aligned}$$

and so on. In general, we may write

$$N_i = \sum_{j=1}^{n} a_{ij} \, D_j \tag{17}$$

where

$$a_{ij} = 0 \; , \qquad i > j \; ,$$

$$a_{ii} = 1 \; ,$$

$$a_{ij} = K_i \, a_{i+1,j} \; , \qquad i < j \; .$$

Equation (17) is the key equation of the hatchery optimization process because it relates the lot population at any time period to the (as yet unknown) releases D_i. The constraint inequalities in (10) can now be written

$$C_i \sum_{j=1}^{n} a_{ij} \, D_j \leq F_i \; , \qquad i = 1, 2, \ldots, n. \tag{18}$$

Let V_i be the value per fish of fish released at time t_i, and let E_i be the total expenditure in feed for a fish release at t_i. Then the profit per fish of fish released at time t_i is $P_i = V_i - E_i$, and lot optimization means we want to select the set of releases D_i which maximizes the objective function

$$\text{Total Profit} = \sum_{i=1}^{n} P_i \, D_i \; . \tag{19}$$

Since negative releases have no meaning, we must also impose the constraint

$$D_i \geq 0 \qquad i = 1, 2, \ldots, n. \tag{20}$$

Thus, the lot optimization problem consists of selecting the releases D_i which maximize (19) subject to the constraints of (18) and (20).

This formulation of the lot optimization problem places the problem in the area of mathematics known as linear programming, and several techniques exist for obtaining computer generated solutions to the problem. The HATCH model uses an algorithm known as the revised Simplex algorithm (see Garvin [5]). After the releases D_i have been obtained from the revised Simplex algorithm, the initial number of ponded fish is computed from equation (17) with $i = 1$. The egg requirements are then computed as in Section II.3 ,

$$E = N_1/(S_F \cdot S_E) .$$

As in Section II.3 the above derivation applies to fish which reside in a hatchery one year or less. The overlap modification applied in that section can also be used to modify equation (18) for 2 year fish.

Once the machinery has been developed to do lot optimization, it is a simple step to perform hatchery operation. The term hatchery optimization means the determination of a set of releases that maximize the economic contribution of <u>all</u> of the lots in the hatchery. Since each of the lots competes for water, only the most economically productive lots will be selected, and the poorer

producing lots will be ignored. This gives a species selection capability to the model in addition to the size and time of release selection capability.

The equations for hatchery optimization are obtained by simply adding some superscripts to the lot optimization equations. We shall use the superscript ℓ to denote lot ℓ. Assume that there are L lots in the hatchery, and let W_i be the total water available to the hatchery in time period i. Then the total water constraint equation analogous to equation (18) is

$$\sum_{\ell=1}^{L} C_i^{\ell} \sum_{j=1}^{n^{\ell}} a_{ij}^{\ell} D_j^{\ell} \leq W_i \ . \tag{21}$$

Equation (21) states that the total water requirements of all lots simultaneously cannot exceed the total flow to the hatchery. The objective function becomes

$$\text{Total Hatchery Profit} = \sum_{\ell=1}^{L} \sum_{i=1}^{n^{\ell}} P_i^{\ell} D_i^{\ell} \ , \tag{22}$$

and we still must have

$$D_i^{\ell} \geq 0 \ . \tag{23}$$

Thus, the hatchery optimization problem is simply an expanded version of the lot optimization problem, and the revised Simplex algorithm can be used to obtain the solution in this case as well.

II.5. Ponding and Planting

After the egg computations have been completed for a lot, for each time period HATCH computes the population of the lot, the total water requirements of the lot and assigns ponds to the lot. The pond sizes are provided by the user in terms of the maximum GPM inflow that each pond can accept. Ponds are assigned to a lot according to the following rules which are a close approximation to standard hatchery practice:

a. Fish of different lots cannot share ponds.

b. Age 0 fish and age 1 fish of the same lot cannot share ponds.

c. The number of ponds assigned to the fish is the minimum number required.

d. Once fish have been assigned a pond, they keep the pond until additional pond space is required or a release occurs.

The model also has an input option which permits the user to reserve specific ponds for a lot.

All ponding computations are bypassed when the number of ponds in the hatchery is set to 1. In this case the model assumes that all fish can share a single pond and restrictions due to pond space conflicts are avoided. This option is of particular value in applying HATCH to hatchery design problems in which the determination of the number and sizes of the hatchery ponds is an important problem.

As the HATCH model processes the pond requirements for each

time period, it also checks for fish releases. Two types of releases can occur -- planned releases and unplanned releases. A planned release is a release that was specified by the user in the input to the model or which was determined by the lot/ hatchery optimization process. An unplanned release occurs whenever there is insufficient water or pond space to satisfy the requirements of a lot.

The HATCH model computes the crowding factor of the fish in the ponds at each time period. The crowding factor is defined to be the ratio of the water required by the lot to the pond space allocated by HATCH. Whenever this ratio exceeds 1, the lot has exceeded the holding capacity of the ponds as specified by the capacity tables, and an unplanned plant occurs. In this case, enough fish are released so that the remaining fish have a crowding factor of 1. An input option is available which permits the user to specify a crowding factor for a lot that is other than 1.

For each release that occurs (both planned and unplanned) the HATCH model records the number of fish released, the date of release, and the size of the fish at release. This data is passed to the fishery model for use in the fishery benefit computations.

II.6. Hatchery Costs

The costs of hatchery operation are broken down into investment costs and operating costs. The investment costs are based on the initial investment, the interest rate and the amortization period specified by the user. The HATCH model assumes that the initial investment has been borrowed at the given interest rate and that the loan period is the same as the amortization period. HATCH uses a standard mortgage payment schedule to compute interest costs. The formula for computing a monthly mortgage payment is

$$P = L \frac{M}{1 - (1+M)^{-n}}$$

where

P -- monthly payment,

L -- loan amount,

M -- monthly interest rate,

n -- loan period in months.

The average annual interest cost I and capital cost C are then computed using

$$I = (nP - L)/A$$

$$C = L/A$$

where A is the amortization period in years. The sum $I + C$ is the total annual capital cost of the hatchery.

The annual hatchery operating costs consist of base crew wages, helper wages, feed costs, supply and maintenance costs, an overhead cost, a pumping cost, trucking costs associated with fish that are transported from the hatchery to remote release sites, and a water reuse (temperature control) cost. The annual base crew wage is independent of the amount of fish reared in the hatchery. However, the user specifies the total pounds of fish that the base crew can rear and the incremental poundage that can be reared with the addition of a helper. Whenever the total poundage of the releases exceeds the capacity of the base crew, a sufficient number of helpers is added to the crew on a full-time basis, and their salaries are added to the total wage cost. The user specified overhead rate is then applied to the total wage cost to obtain the hatchery overhead cost.

The feed cost for the hatchery is the sum of the pounds of feed fed to each lot times the cost of the feed. Maintenance and supply costs are fixed costs and do not vary with the amount of fish reared.

Pumping costs are obtained by multiplying the total amount of water pumped (in GPM) by the cost of pumping a single GPM as specified by the user. Trucking costs are based on the cost/mile of operating a truck, the distance the fish are hauled and the number of trips required. Trucking costs are based on the use of

a standard 1000 gallon tank truck which carries 830 gallons of water.

Water reuse costs are incurred when pond temperatures differ from the ambient source water temperature and reflect the cost of achieving this temperature differential. Four factors determine this cost: the temperature differential, the BTU's required to heat one GPM one degree Fahrenheit, the BTU's required to cool one GPM one degree Fahrenheit, and the cost of a BTU. All of these factors are under input control.

II.7. Fishery Benefits

The fishery model is used to compute the economic contribution to the fisheries and the escapement returns for each lot of fish in the hatchery. Two principles form the basis of the fishery model. First, the number of fish of each age that are caught in a fishery is directly proportional to the number of fish released. For example, we may say that .005 of the Coho released from a hatchery are caught as three year old fish in the Washington troll fishery. This type of information can be derived directly from hatchery production records and fishery catch statistics, and this approach greatly simplifies the fishery model since all questions concerning the dynamics of the fisheries are avoided. In essence, we are saying that for hatchery analysis we are only interested in the pattern of the catch in the fisheries,

and we need not be concerned with the much deeper question of why the pattern exists.

The second principle of the fishery model is that the fishery contributions for each release are dependent upon the time of the release and the size of the fish in the release, and that this influence is a major factor which must be accounted for.

Within this framework, the fishery model is relatively straightforward. For each lot of fish the user specifies a range of release times and sizes. Then for each combination of size and time of release performance data is specified for each fishery. This data consists of the age of the fish, the fraction caught of the release, the average weight/fish of the catch and the dollar/pound value of the catch. Escapement data is also keyed to release size and time, and this data consists of the age of the fish, the escapement fraction, the fraction of the escapement that are male, and the value/fish of spawned fish and excess fish.

A fishery performance table is constructed for each lot. The entries in the table describe the catch contribution of a release which occurs at the specified size and time. For example, suppose that fishery performance data exists for Coho salmon at two sizes of release, April 1 and May 1 and at three time of release, 15, 20 and 25 fish/pound. Then the table contains fishery performance data for each of the six combinations of

size and time of release. The HATCH model uses two-dimensional linear interpolation to compute the performance for other combinations of size and time of release, e.g., a release on April 15 at 22 fish/pound.

For every release of each lot of fish, the fishery model uses the size and time of the release to compute the number of fish caught in fishery, the weight of the fish, the value of the fish and the total value of the catch. At the same time the escapement results for the release are determined. The sole exception to this procedure is that any unplanned release of age 0 fish of a 2 year fish is considered to have a zero fishery contribution.

In order to make the benefit:cost analysis more precise, provision has been made in HATCH to discount the fishery benefits by the formula

$$V = \frac{P}{(1+D)^{i}}$$

where P is the catch value of a hatchery fish that is caught at age i and V is the present value of that future benefit.

The catch and economic statistics are summarized for each lot of fish that is reared. The fishery economic benefits and hatchery costs are combined in a benefit:cost analysis which is the final task of the HATCH model.

III. HATCH Input

Although the HATCH model is written in FORTRAN the standard input procedures provided by the FORTRAN format statement are not used because of the lack of flexibility and the error checking weaknesses of this statement. Instead, all input to HATCH is based on the use of keywords and free-field formats. Each data card contains a keyword which begins in column 1 and which is followed by free-field data separated by blanks or commas. Certain data cards may use more than one keyword. The keyword on each card serves a dual purpose. It notifies the input processor of the type of data on the card, and it provides the user with a means for quickly locating a specific data item when scanning the input listing. In addition, the use of keywords makes the input to the model reasonably order independent in that a strict sequence of cards is not required. Certain precedence requirements do exist, primarily in the fishery input.

The input to HATCH is divided into four main sections which have keywords beginning with an asterisk. These keywords are:

*HATCHERY,
*LOT,
*COST,
*FISHERY.

Each of these asterisk keyword cards is followed by other (non asterisk) keyword data cards. The last card in each group of

input that begins with an asterisk keyword card must be blank. That is, each group on input cards must have an asterisk keyword card as the first card and a blank last card.

The *HATCHERY card is the header card for the group of data cards which describe the physical parameters of the hatchery. The biological parameters and release information for each lot of fish is headed by a *LOT card. The investment costs and operating costs of the hatchery are headed by the *COST card, and the fishery performance data for each lot of fish are headed by a *FISHERY card. A summary of the four data groups is given in Appendix A.

All *HATCHERY, *LOT and *COST data groups must precede the first occurrence of a *FISHERY data group. A special asterisk card, *END, must be used to indicate that all *HATCHERY, *LOT and *COST data have appeared. A *END card must also be used to indicate that all *FISHERY data cards have appeared. The *END card is not followed by a blank card (see the input listing in Appendix B).

Since a complete analysis of a hatchery may require several runs of the HATCH model with only minor variations to the input deck, provision has been made for reading data from alternate files as well as the card reader. The user may store the card images for the *HATCHERY, *LOT and *COST data groups in a file written on magnetic tape or other storage medium. To make this

data available to the HATCH model, the file is assigned to FORTRAN unit 1 using system control cards. In the same manner, the *FISHERY data items can be stored and assigned to FORTRAN unit 2 for input to the HATCH model.

The input sequence to HATCH proceeds as follows. First the model checks unit 1 to see if any *HATCHERY,*LOT, or *COST data reside on the unit. If so, it processes this data until a *END or end-of-file is reached. It then checks the card input for additional *HATCHERY, *LOT or *COST data. If no data exists on unit 1, the processor immediately accepts card data for *HATCHERY, *LOT and *COST. In both cases, the model will process <u>card</u> input until a *END card is reached.

After reaching the first *END card the input processor checks unit 2 for *FISHERY data. If any data resides on the unit it is accepted by the processor until either a *END card or an end-of-file mark is reached. The processor then checks the card reader for additional *FISHERY data. If no data exists on unit 2 the processor immediately accepts data from the card reader. In both cases, card input is accepted until a *END is reached. This terminates input processing.

The use of key words by the HATCH model enhances the above process by providing a simple technique for overriding previously entered data. For instance, if the user wishes to change a data item entered from the unit 1 data set, it is not necessary

to recreate or alter the data set. Instead, the data item is placed in the input card deck. Since card data is processed after unit 1 data, the new value for the data item will override the value obtained from unit 1. The *FISHERY data on unit 2 is treated slightly differently because of the complex indexing that is done by HATCH to minimize the storage requirements for this data. Data changes to a portion of a *FISHERY data group require that the entire group be reentered from cards.

Several conventions have been followed in the input data and in the following descriptions of the input. A standard format of month number/day number is used for all date input, e.g., June 10 is 6/10. All dates are converted to the corresponding model time period. Days 1-15 of a month correspond to the first half-month period, and days 15-31 correspond to the second half-month period.

Certain keyword cards in the *LOT section have an optional keyword, AGE-1, which appears in brackets in the data description. This is used to distinguish the parameters of age 0 and age 1 fish for a 2 year lot. This keyword must appear whenever age 1 parameters are entered.

Several keyword cards use a positional notation to distinguish time. For instance, the first number of 12 numbers which describe monthly data refers to January and the last refers to December. Consequently, leading zeros are required to maintain

the correct sequential correspondence if the data begins in a month other than January.

A group of data terms which can be repeated on a card is indicated by a terminal ellipsis.

The remainder of this section gives the formats of each of the keyword cards used by the HATCH model. The card descriptions are grouped according to the asterisk card they follow.

III. 1. Hatchery Data

*HATCHERY

No additional data appears on this card. The card is used solely to indicate the start of hatchery data.

NAME   hatchery name

The hatchery name is used to identify the output. It may begin in any column after 5 and may fill the rest of the card.
Example:

```
NAME     MINTER CREEK TEST 5
```

FLOW   water available to the hatchery by month (12 numbers)

The units of flow input are gallons/minute (GPM). The first number on the card in the January flow; the final number is the December flow. The flow may be either integers or decimal numbers.
Example:

```
FLOW     9000,9000,9000,8500,8000,8000,7500,7000,8000,8500,8200,9000
```

WATER semi-monthly ambient source water temperatures (24 numbers)

The unit of temperature is Fahrenheit degrees. The numbers may be integer or decimal. The first number is for the first half of January; the last is for the last half of December. More than one card may be used.
Example:

```
WATER    42,42,43,43,43,44,44,45,47,49,51,52
WATER    54,55,55,54,54,53,50,49,48,46,44,43
```

PONDS The number of ponds in the hatchery.

The maximum number of ponds is 100.
Example:

```
PONDS    26
```

SIZES The capacity (in GPM)of the ponds in the hatchery.

This card is used to give the capacity for each of the rearing ponds in the hatchery. The PONDS card must preceed the SIZES card, and as many SIZES cards as necessary may be used to provide the capacity information. The SIZES card uses two special formats to specify pond capacities:

$$(P_1, P_2, \ldots P_n = CAP) \ ,$$

$$(P_1 - P_n = CAP) \ .$$

The first format indicates that ponds $P_1, P_2, \ldots, P_n$ all have a capacity of CAP GPM. The number of ponds listed in this manner is limited only by the width of the card. The second format indicates that ponds P_1 through P_n all have capacity CAP. More than one set of parentheses may appear on a SIZES card. The pond numbers used by HATCH begin with 1 and end with the number of ponds in the hatchery. The following example assigns sizes to ponds 1 through 26.
Example:

```
SIZES    (1,3,5 = 250), (6 - 10 = 700), (25,26 = 1000)
SIZES    (18,19,2,4 = 700), (11 - 18 = 800)
```

III.2. Lot Data

*LOT   Lot name, number of years in hatchery

Lot name (from 1 to 20 characters) identifies the lot. The number of years in the hatchery is either 1 for fish residing one year or less in the hatchery, or 2 for fish which reside from 1 to 2 years in the hatchery. The maximum number of lots in a hatchery depends on the years/lot parameter. The maximum is 10 for all 2 year lots or 20 for all 1 year lots.
Example:

```
*LOT     COHO, 2
```

SURVIVAL egg survival, fry survival,12 monthly survival rates
SURVIVAL AGE-1 12 monthly survival rates

The first form of the SURVIVAL card is used to give the total egg survival rate, total fry survival rate and the monthly pond survival rates. This card is used for 1 year fish and for age 0 of 2 year fish. The second form of the SURVIVAL card gives the pond survival rates for age 1 of a 2 year fish.
Example:

```
SURVIVAL .7,.75,.9,.9,.9,.93,.93,.93,.95,.95,.95,.95,.96,.96
SURVIVAL AGE-1  .96,.96,.96,.96,.96,.96,.96,.97,.97,.97,.98,.98
```

TIME   spawning date, fry date, pond date, adult return date

This card specifies the dates on which the following events occur:
- spawning date -- date egg taking begins,
- fry date -- date hatching begins,
- ponding date -- date fish are transferred to rearing ponds
- adult return date -- date adult return begins.

These dates are used in conjunction with the WATER card (see below) to specify special hatchery water requirements.
Example:

```
TIME     10/15, 1/1, 3/1, 9/1
```

WATER   egg water, fry water, adult water

This card is used in conjunction with the preceeding TIME card to specify special hatchery water requirements (in GPM) for holding eggs, fry and spawners. The egg water requirements apply between the spawning date and the fry date; the fry water requirements apply between the fry date and the ponding date; the adult water requirements apply between the adult return date and the spawning date. The water requirements specified on this card are reserved during these time periods, and this water is not available for rearing pond use. The water requirements specified on this card are fixed and are independent of the number of eggs, fry or adults, so average values should be used.

The WATER card is optional. Zero values are assumed by HATCH when it is not used.

Example:

```
WATER    300, 450, 3000
```

S-T TEMP [AGE-1] temperature coordinates for water requirements table
S-T WT   [AGE-1] weight coordinates for water requirements table
S-T PPG [AGE-1] (temperature, weight, PPG), ...

These three data cards are used to specify the two dimensional table which gives the pounds of fish that one GPM inflow to a pond (PPG -- pounds per gallon) can hold as a function of pond water temperature (F°) and fish weight (fish per pound). The TEMP card and WT card specify the coordinate values of the table and must preceed the PPG card. The PPG card gives the table entries. Multiple PPG cards are permitted. The maximum number of temperature coordinates is 5. The maximum number of weight coordinates is 7. If AGE-1 values are not specified for a 2 year fish, then the age 0 values will be used.

Example:

```
S-T TEMP 38, 60
S-T WT   15, 500
S-T PPG  (38,15,7), (38,500,3), (60,15,2)
S-T PPG  (60,500,.5)
```

RATION [Age-1] monthly rations (% body weight)

This card specifies the growth schedule for the lot by the amount of food fed as a percentage of body weight.

Example:

```
RATION   0,0,3,3,5,4
```

WEIGHT [AGE-1] monthly weight schedule (fish/pound)

This card specifies the growth schedule of the lot by the monthly weight of the fish.
Example:

```
WEIGHT   0,0,850,450,180,100
```

PDWT weight of fish when first ponded (fish/pound)

This card gives the weight of the fish when first placed in rearing ponds and initiates the growth process.
Example:

```
PDWT     1100
```

```
GROWTH   seven  λ  growth parameters
GROWTH A eight  α  growth parameters
GROWTH   lot name
```

These cards provide the values of the λ and α parameters for the Stauffer growth equations (see Section II.2.). The first two cards are used to provide the values of the parameters. The third card is used when the parameters of the current lot are the same as a previous lot. The maximum number of different sets of growth parameters is 5.
Example:

```
GROWTH   DELAYED COHO
```

FEED [AGE-1] feed name, moisture content, cost ($/pound)

This card gives the name of the feed (10 characters or less), the fraction of the feed that is water, and the feed cost.
Example:

```
FEED     OMP,.32,.25
```

GCT [AGE-1] semi-monthly pond water temperatures
GCT [AGE-1] lot name

These cards give the pond water temperatures for water reuse systems in which the pond temperatures differ from the ambient source water temperatures. (GCT -- growth control temperature). The first version of this card is used to give the temperature values in degrees Fahrenheit. Multiple cards are allowed. The second version of the GCT card is used when the temperatures of this lot are the same as a previous lot. A maximum of 5 different sets of pond water temperatures (other than the ambient temperatures) may be stored in HATCH.

Example:

```
GCT      45,45,45,45,45,45,47,47,47,47,47,47
GCT      47,47,47,47,47,47,45,45,45,45,45,45
```

PLANT AGE-1 (date, fraction released, fraction trucked, distance trucked), ...

This card gives the required data for user specified fish releases. For each release the user must specify the date of the release, the fraction of the lot population released, the fraction of the release that is trucked to a remote planting site, and the distance the fish are hauled. The latter two numbers are used to compute trucking costs. The fraction released refers to the current population. Therefore, the final release always has a fraction of 1. To override PLANT data which appears on unit 1, the first PLANT card for the lot must be blank.

Example:

```
PLANT
PLANT    (4/15,.5,.5,25), (6/1,1,0,0)
```

EGGS M1, number of eggs
EGGS M2, date, capacity fraction
EGGS M3, date, capacity fraction
EGGS M4, capacity fraction
EGGS M5, capacity fraction
EGGS M6
EGGS M7

These seven cards give the various options available for egg computations. For method M1 the user specifies explicitly the number of eggs. In methods M2 and M3 the user specifies a date and the fraction of the hatchery water to be utilized by the lot on that date. In method M2 the fraction refers to water that has not been utilized by a higher priority lot (unused water). In method M3 the fraction refers to the total hatchery flow, used or unused. In methods M4 and M5 the user specifies only a capacity fraction. For these two methods the HATCH model multiplies F_m (see Section II.3.) by the capacity fraction to obtain the number of eggs. Method M4 refers to unused water, M5 to total flow. Method M6 is for lot optimization and method M7 is for hatchery optimization.

Example:

```
EGGS     M2, 9/15, .75
```

PONDS [AGE-1]   list of pond numbers

Pond numbers listed on this card will be reserved for either age 0 or age 1 fish of this lot. This card can be used to insure that the fish of the lot are placed in the specified ponds. This card is optional.

Example:

```
PONDS  AGE-1   2,5,17,26
```

C-F [AGE-1]   crowding factor

This card specifies the maximum permissible crowding factor (see Section II.5.). An unplanned plant will occur whenever the specified factor is exceeded. This card is optional.

Example:

```
C-F      1.25
```

FECUND   (age, number of eggs), ...

This card specifies the fecundity of the fish for the listed ages. This data is used to compute the number of female spawners required.

Example:

```
FECUND   (3,2500), (4,3500), (5,4500)
```

PRIORITY lot priority

This card gives the priority number of the lot for water and pond space allocation purposes. The highest priority is 1 and the lots must be assigned sequential priority numbers.
Example:
PRIORITY 2

TRUCK (fish weight, pounds/gallon), ...
TRUCK lot name

The TRUCK card is used to specify the maximum density (pounds/gallon) of fish in a tank truck as a function of fish weight (fish/pound). A maximum of six weights may be specified. The second version of the TRUCK card is used when the density data is identical to the data of a previous lot. A maximum of 5 distinct sets of trucking density data may be stored in HATCH. The density data is used to determine the number of pounds of fish that can be hauled in one truck load when being transported to a remote release site.
Example:
TRUCK (75,.5), (50,.75), (30,1), (15,2)

FISH moisture content

This card gives the moisture content of fish flesh for the lot and is optional. The default value is .75.
Example:
FISH .8

III.3. Cost Data

The input data described in this section covers the investment and operational costs of the hatchery. Since the cost data cards are very simple, all examples are deferred until the end of the section. Costs are all given in dollars. All cost data (including the *COST card) are optional.

*COST

No additional information appears on this card. It is used solely to indicate the beginning of the cost input.

INVEST	the dollar investment in the hatchery
INTEREST	the annual rate on the investment
AMORT	the amortization period for the investment
DISCOUNT	the rate for discounting future benefits
BASECREW	number of men, total monthly salary, maximum poundage
HELPER	monthly salary/helper, incremental poundage
MAINT	monthly maintenance cost
SUPPLY	monthly supply cost
OVERHEAD	overhead rate
PUMP	minimum flow level, pumping cost/GPM
	The minimum flow level is the flow in GPM that is available to the hatchery without pumping. The hatchery incurs pumping costs whenever this level is exceeded.
TRUCK	cost/mile
REUSE	BTU/GPM heating requirements, BTU/GPM cooling requirements, cost/BTU

Examples:

```
INVEST     1000000
INTEREST   .08
AMORT      30
DISCOUNT   .08
BASECREW   4,3200,100000
HELPER     750,25000
MAINT      300
SUPPLY     300
OVERHEAD   .22
PUMP       3500,.00001
TRUCK      .45
REUSE      .01,.02,.0004
```

III.4. Fishery Data

The fishery data cards specify the fishery performance characteristics for each lot of fish. Because of the large amount of data that can be required, the fishery data is more structured in that a stricter ordering of the cards is necessary. The SIZES, TIMES, AGES and FISHERIES cards must preceed all other fishery data cards because these cards initiate critical index calculations for the fishery model. A SIZETIME card must preceed each group of fishery performance data cards, NAME, DATA and ESCAPE. The formats of the fishery cards are given below; reference should also be made to the fishery data examples in Appendix C.

*FISHERY lot name

This card is the first card of the fishery data for the specified lot name. The lot name must have appeared previously on a *LOT card.
Example:

```
*FISHERY  DELAYED COHO
```

SIZES weight at release coordinates (fish/pound)

This card gives the release weight coordinate values for the fishery performance table. A maximum of four weights may be specified. If no size and time of release information is available, this card must be left blank. In this case, every combination of size and time of release has the same fishery performance parameters.
Example:

```
SIZES     25,15,10
SIZES
```

TIMES date of release coordinates

This card gives the release date coordinate values for the fishery performance table. A maximum of four dates may be specified. This card must be left blank when no size and and time of release data is available.
Example:

```
TIMES     3/15, 4/15, 5/15
```

AGES youngest fishery age, oldest fishery age

This card specifies the age span of the fish in the fishery and/or in the escapement. For Coho salmon these values would typically be 2 and 3, for Chinook 2 and 5.
Example:

```
AGES     2,3
```

FISHERIES number of fisheries

This card specifies the number of different fisheries for the lot for which catch data will be provided. The maximum number of fisheries for any one lot is immaterial except in that the total number of fisheries for all lots may not exceed 200.
Example:

```
FISHERIES   8
```

SIZETIME weight, date

The SIZETIME card specifies a coordinate pair of release sizes and times. All fishery performance data which follows this card applies to the specified size and time coordinate pair until either another SIZETIME card is reached or the fishery data for the lot is terminated by a blank card. This card must be left blank when the SIZES and TIMES cards are blank.
Example:

```
SIZETIME    25, 4/15
```

NAME fishery name

The NAME card specifies a fishery name (a maximum of 20 characters). All DATA cards which follow this card give performance data for the named fishery. The fishery names in each set of SIZETIME data must be identical.
Example:

```
NAME        P. SOUND GILL NET
```

DATA   age, fraction caught, average weight/fish, dollar/pound catch value

This card gives the fishery performance data for fish of the specified age. The fraction caught is the fraction of the number of fish released at the hatchery that are caught in the fishery. The weight per fish is the average weight (pounds) of the fish at the specified age in the fishery. For sport fisheries, it is generally simplest to artificially set the weight to 1. The dollar/pound catch value then gives a dollar/fish value for sport fish. The total number of data cards for all sizes and times of release and all lots may not exceed 1000.

Example"

```
DATA     3,00027,7.8,.95
```

ESCAPEMENT   age, escapement fraction, male fraction, excess male value, excess female value, spawned male value, spawned female value

The card specifies the escapement performance data for fish of the specified age. The escapement fraction is the fraction of the hatchery fish released that return to the hatchery for spawning. The male fraction specifies the fraction of the escapement that is male. The excess male and female values are the dollar/fish values of the escapement that is not required for spawning. The spawned male and female values are the dollar/fish values of the carcasses of the fish used for spawning.

Example:

```
ESCAPEMENT   3,.0012,.45,2.00,6.00,.50,.50
```

EQUAL   lot name

When two lots of fish have identical fishery performance parameters, this card can be used to eliminate the need to replicate the input data. The lot name refers to a lot for which all fishery data has been entered. In this case, the EQUAL card is the only card that is required after the *FISHERY card.

Example:

```
EQUAL    DELAYED COHO
```

III.5. Input Error Checking

The HATCH program performs a substantial amount of input testing as the data cards are being processed, and error messages are printed when input errors are detected. For the most part, these messages are self-explanatory. However, input errors frequently occur which make it impossible to fully identify the cause of the problem. In this case a generic error message, ***DATA ERROR***, is printed. In all cases, the input card which caused the error is also printed. Generally, the above error message is caused by missing data, and the problem can be detected by rechecking the card format.

When an input error occurs, the HATCH model does not perform any calculations. However, since the standard FORTRAN input procedures are not used, and input error does not immediately terminate HATCH execution. Instead, all remaining input cards will be examined for possible errors. This feature greatly reduces lost time that can be caused by multiple input errors.

IV. HATCH Output

The output from the HATCH model consists of five types of reports: A hatchery performance summary for each lot, a water usage plot, a pollution analysis report, a fishery benefits summary for each lot and an economic analysis report. A complete set of output from HATCH is provided in Appendix C. To a large extent the output is self-explanatory, and only brief descriptions of these reports are given below.

The hatchery performance summaries are presented in lot priority order. The pond water temperature column and the source water temperature column will be identical unless water reuse data is supplied. The units for the daily ration column are percent body weight, i.e., 3.10 means the fish are fed 3.1% of their body weight daily during the time period. The food conversion factor for a time period is the ratio of the total amount of food fed to the incremental weight gain. The water available column gives the amount of unused water in the hatchery for the time period before the current requirements have been satisfied. The unused water column gives the amount of water left after the current requirements have been satisfied. A zero in this column indicates that the hatchery is full. The final column of this report gives the percentage of the total hatchery water that is allocated to the lot. The pond space column gives the total pond space (in GPM) that has been allocated

to the lot. The next to last column gives the percentage of the allocated pond space that is actually required by the lot. This column and the pond space column are meaningless when the pond calculations have been bypassed. Whenever an unplanned plant occurs it will be flagged with a double asterick. Whenever the growth schedule is altered because of the maximum ration limit, the daily ration is flagged with a single asterisk.

The water usage plot shows the overall allocation of water to all lots in the hatchery. The plot indicates the water requirements of each lot and age group for every time period.

The water pollution report provides a summary of the total amount of pollutants produced daily in the hatchery and the concentration of these pollutants in the hatchery effluent. This report gives the total source water flow, the total weekly feed, the total daily feed and the dry weight of the total daily feed for each time period. The total daily feed is multiplied by the following constants (see Wood [6]) to obtain the daily production of pollutants.

Pollution Parameter	HATCH Abbreviation	lb/lb of food
Ammonia nitrogen	Ammonia	.032
Biochemical oxygen demand	BOD	.34
Nitrate nitrogen	Nitrate	.087
Oxygen consumption	Oxygen use	.25
Phosphate	Phosphate	.005
Settleable solids	Solids	.30

For each of the above pollution parameters the daily production and the concentration (pounds/GPM) is given for every time period.

The fishery contribution reports gives the total catch, average value per fish and catch value for each age and for each fishery to which a lot contributes. The report summarizes the contributions of all releases for the lot. It also gives the escapement statistics for the lot and an overall summary of egg requirements and catch activity.

The economic analysis report summarizes both the capital costs and operating costs of the hatchery, lists the total value of the catch. It also gives the benefit:cost ratio for the hatchery when operated according to the management policy specified by the input data.

V. Other Hatchery Applications

The data handling and analysis techniques developed for the HATCH model have important applications to hatchery management outside of production planning. It is commonly estimated that a hatchery manager spends at least 10-20% of his time in report preparation activities. A large fraction of these activities consists of simple but time consuming computations and data recording required for hatchery reports. Typical of the type of calculation required is the conversion from pounds of food per pond to a percent body weight ration. A much more efficient approach to weekly or monthly report generation would be to use an automated system in which the hatchery operator would need only to record the data input from his hatchery. All computations and the actual reports preparation could then be computer generated. At the same time the data could be stored in a data base for input to future hatchery analyses. Hatchery reports could either be produced at a central site and mailed to the manager, or they could be printed at the hatchery through the use of teletype equipment. In either case, the hatchery operator is freed from a tedious task and would be able to devote more time to his primary task of hatchery management. This type of procedure is well within the capabilities of current technology.

A particularly useful application of HATCH model techniques is in the area of growth and feed computations for the hatchery. Because of the complexity of the growth process and its dependence on pond water temperature, the determination of feed rates is a constant problem. The growth equations in the HATCH model can be used to provide recommended feed rates to the hatchery manager as frequently as desired. This can be especially useful in years for which the actual temperature profiles differ substantially from the average profiles that were used during production planning. The same growth equations can be used to obtain initial growth schedules and to compute modifications that may be required because of unusual circumstances.

In general, the day to day operation of a hatchery contains many opportunities for significant improvements through the application of automated data handling and analysis techniques. However, one important fact must always be remembered. The purpose of the HATCH model and other automated techniques is to serve as <u>tools</u> for the hatchery manager; they cannot possibly replace him. The ultimate value of these techniques lies in their ability to enhance the skills of the manager and, consequently, to increase hatchery productivity.

Appendix A

HATCH Input Summary

References

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Appendix A

HATCH Input Summary

The input to HATCH consists of four classes of data -- hatchery physical data, cost data, lot biological and management data, and fishery performance data. The input content for each of these classes is summarized below. An asterisk denotes optional data.

Hatchery Data

- o Hatchery name
- o Monthly average water flows to hatchery
- o Semi-monthly ambient water temperatures
- o number of ponds
- o pond sizes

Cost Data -- All cost data are optional

- o Investment amount
- o Interest rate
- o Amortization period
- o Discount rate
- o Base crew salary and production capacity
- o Extra helper salary and production capacity
- o Maintenance costs
- o Supply costs
- o Overhead rate
- o Pumping costs
- o Trucking costs
- o Water reuse and temperature control costs

Lot Data

- o Lot name
- o Number of years lot is in hatchery (1 or 2)
- o Lot priority
- o Egg and fry survival rates
- o Monthly survival rates for ponded fish
- *o Water requirements for eggs, fry and spawners
- o Dates for taking eggs, egg hatching, ponding of fish, and spawner return
- o Table of pond capacities as a function of pond water temperature and fish size
- *o Semi-monthly pond water temperatures
- o Fish weight at initial ponding
- o Monthly growth schedule (by ration or weight)
- o Stauffer growth equation parameters
- o Feed costs and moisture content
- *o Schedule of planned fish releases
- o Egg computation method
- *o Pond reservations
- *o Crowding factor
- *o Fecundities
- *o Table of tank truck capacities as a function of fish weight
- *o Moisture content of fish flesh

Fishery Data

- o Lot name
- o Range of sizes of fish at release time
- o Range of dates of release
- o Number of fisheries
- o Age range of lot in the fisheries
- o Fishery names
- o Fishery performance data -- age, percentage contribution, average weight/fish, dollar/pound catch value
- *o Escapement data -- age, percentage escapement, male percentage, dollar/fish values for excess males, excess females, spawned males, spawned females.

Appendix B

HATCH Input Example

```
*HATCHERY
NAME  MINTER CREEK BASELINE
FLOW 15120,15120,15120,15120,15120,15120,15120,15120,9340,9340,9340,9340
POND  1
WATER  40,41,41,43,44,45,47,48,50,51,52,53,53,54,54,53,53,51,50,48,46,46,44,42

*COST
INVEST  1000000
INTEREST  .06
AMORT  30
DISCOUNT  .06
BASECREW   4,2952,100000
HELPER  600,25000
MAINT  100
SUPPLY  150
OVERHEAD  .22

*LOT  COHO  2
PRIORITY  1
SURVIVAL .935,.924,1.,1.,.998,.988,.994,.997,.996,.998,.997,.996,.998,.997
SURVIVAL  AGE-1  .999,.999,.999,.998,.995,.994,.999,1.,1.,1.,1.,1
WATER 200,200,0
TIME  1/1,2/15,4/1,10/1
PDWT  1107.
WEIGHT  1107,1107,1107,1107,591,252,135,84,61,52,45,38
WEIGHT  AGE-1  35.5,34.4,33.1,29.2,16.2,15.3,11.9,9.0,9,9,9,9
GROWTH .0397,.0280,.0321,.2165,-8.82,2.51,.171,.3333
GROWTH A  -15.949,1.3849,-.0460180,.00069698,-.0000038991,.0383,.3333
FEED  .32,OMP,.21
FEED  AGE-1  .32,OMP,.21
PLANT  AGE-1  (4/15,1,0,0)
EGGS  M4,1
FECUND  (3,1885)
S-T   TEMP 38,48,58,63
S-T  WT  1000,500,100,50,33,25,15
S-T   PPG (38,1000,3.5),(38,500,5.0),(38,100,8.0),(38,50,11.0),(38,33,15.0)
S-T   PPG (48,1000,2.7),(48,500,4.0),(48,100,6.0),(48,50,10.0),(48,33,14.0)
S-T   PPG (58,1000,2.2),(58,500,3.0),(58,100,4.5),(58,50, 7.0),(58,33,10.0)
S-T   PPG (63,1000,1.7),(63,500,2.0),(63,100,3.5),(63,50, 5.0),(63,33, 7.0)
S-T   PPG (38,25,20),(48,25,16),(58,25,12),(63,25,9)
S-T  PPG           (38,15,25),(48,15,18),(58,15,15),(63,15,10)
S-T  TEMP  AGE-1  38,48,58,63
S-T  WT  AGE-1  1000,500,100,50,33,25,15
S-T  PPG AGE-1 (38,1000,3.5),(38,500,5),(38,100,8),(38,50,11),(38,33,15)
S-T  PPG AGE-1 (48,1000,2.7),(48,500,4),(48,100,6),(48,50,10),(48,33,14)
S-T  PPG AGE-1 (58,1000,2.2),(58,500,3),(58,100,4.5),(48,50,7),(58,33,10)
S-T  PPG AGE-1 (63,1000,1.7),(63,500,2),(63,100,3.5),(63,50,5),(63,33,7)
S-T  PPG  AGE-1 (38,25,20),(48,25,16),(58,25,12),(63,25,9)
S-T  PPG  AGE-1  (38,15,25),(48,15,18),(58,15,15),(63,15,10)
C-F    AGE-1  1
C-F   1

*LOT  CHINOOK  1
PRIORITY  2
SURVIVAL .887,.964,1.,.999,.995,.997,.997,.996,.999,1.,.999,.999,.999,.999
WATER  100,100,0
TIME   11/1,1/1,3/1,9/1
WEIGHT  864,864,864,437,187,91.4,49.9,27.5,18.3,16,16,16
PDWT  864
GROWTH   .0397,.0280,.0321,.2165,-8.82,2.51,.171,.3333
GROWTH A  -15.949,1.3849,-.0460180,.00069698,-.0000038991,.0383,.3333
FEED  .32,OMP,.21
PLANT  (6/1,1,0,0)
EGGS . M4,1
FECUND  (3,4644),(4,4644),(5,4644)
S-T   TEMP 38,48,58,63
S-T  WT  1000,500,100,50,33,25,15
S-T PPG (38,1000,3.0),(38,500,4.0),(38,100,6.0),(38,50,8.0),(38,33,11.0)
S-T PPG (48,1000,2.5),(48,500,3.0),(48,100,5.0),(48,50,6.5),(48,33, 9.0)
S-T PPG (58,1000,2.0),(58,500,2.2),(58,100,3.5),(58,50,4.5),(58,33,6.0)
S-T PPG (63,1000,1.0),(63,500,1.2),(63,100,3.0),(63,50,3.5),(63,33,4.0)
S-T PPG (38,25,12),(48,25,10),(58,25,7.5),(63,25,5)
S-T PPG (38,15,13),(48,15,11),(58,15,9),(63,15,5.5)
C-F   1

*END
```

```
*FISHERY COHO
SIZES      37,13.7,13.69,5.2
TIMES      3/15,6/15,8/1
AGES       2,3
FISHERIES 8
SIZETIME  37,3/15
NAME CANADA TROLL
DATA 3, .00822518,  5.53, .57
NAME CANADA NET
DATA 3, .00415405,  7.84, .32
NAME WASH.  TROLL
DATA  3,.00187044,6.41,.57
NAME  WASH. PUGET NET
DATA  3, .00372137, 6.53, .39
NAME WASH. OCEAN SPORT
DATA  3,.00146649,1.,17.50
NAME WASH. PUGET SPORT
DATA  3,.00084279,1.,18.07
NAME OREGON TROLL
DATA  3,.00007840,6.41,.57
NAME OREGON SPORT
DATA  3,.00001388,1.,17.50
ESCAPE 2, .00060800, 1., 1.01,    0,  .40,  0
ESCAPE 3, .00645808, .5, 2.03, 3.23,  .81, .81
SIZETIME  13.7,3/15
NAME CANADA TROLL
DATA 3, .02794298,  5.71, .57
NAME CANADA NET
DATA 3, .01411234,  8.10, .32
NAME WASH.  TROLL
DATA  3,.00635437,6.61,.57
NAME  WASH. PUGET NET
DATA  3, .01264241, 6.75, .39
NAME WASH. OCEAN SPORT
DATA  3,.00498203,1.,17.73
NAME WASH. PUGET SPORT
DATA  3,.00286317,1.,18.37
NAME OREGON TROLL
DATA  3,.00026636,6.61,.57
NAME OREGON SPORT
DATA  3,.00004716,1.,17.73
ESCAPE 2, .00206552, 1., 1.05,    0,  .42,  0
ESCAPE 3, .02193971, .5, 2.10, 3.30,  .84, .84
SIZETIME  37,6/15
NAME CANADA TROLL
DATA 3, .02381436,  5.26, .57
NAME CANADA NET
DATA 3, .01202722,  7.46, .32
NAME WASH.  TROLL
DATA  3,.00541550,6.09,.57
NAME  WASH. PUGET NET
DATA  3, .01077447, 6.21, .39
NAME WASH. OCEAN SPORT
DATA  3,.00424593,1.,17.13
NAME WASH. PUGET SPORT
DATA  3,.00244013,1.,17.62
NAME OREGON TROLL
DATA  3,.00022700,6.09,.57
NAME OREGON SPORT
DATA  3,.00004019,1.,17.13
ESCAPE 2, .00176034, 1.,  .95,    0,  .38,  0
ESCAPE 3, .01869808, .5, 1.90, 3.10,  .76, .76
```

A

```
SIZETIME  13.7,6/15
NAME CANADA TROLL
DATA 3, .04353217,  5.43, .57
NAME CANADA NET
DATA 3, .02198551,  7.71, .32
NAME WASH.  TROLL
DATA  3,.00989942,6.30,.57
NAME  WASH. PUGET NET
DATA  3, .01969551, 6.43, .39
NAME WASH. OCEAN SPORT
DATA  3,.00776147,1.,17.37
NAME WASH. PUGET SPORT
DATA  3,.00446051,1.,17.91
NAME OREGON TROLL
DATA  3,.00041496,6.30,.57
NAME OREGON SPORT
DATA  3,.00007347,1.,17.37
ESCAPE 2, .00321786, 1.,  .98,    0,  .39,   0
ESCAPE 3, .03417972, .5, 1.97, 3.17,  .79, .79
SIZETIME  5.2,6/15
NAME CANADA TROLL
DATA 3, .02468889,  3.81, .57
NAME CANADA NET
DATA 3, .01246889,  5.41, .32
NAME WASH.  TROLL
DATA  3,.12227726,4.42,.57
NAME  WASH. PUGET NET
DATA  3, .03864232, 4.73, .39
NAME WASH. OCEAN SPORT
DATA  3, .02148297, 1, 12.43
NAME WASH. PUGET SPORT
DATA  3,.08863413, 1, 13.36
NAME OREGON TROLL
DATA  3,.00023534,4.42,.57
NAME OREGON SPORT
DATA  3,.00004167,1.,15.17
ESCAPE 2, .00472895, 1.,  .50,    0,  .21,   0
ESCAPE 3, .10457746, .5, 1.05, 1.45,  .42, .42
SIZETIME  13.69,6/15
NAME CANADA TROLL
DATA 3, .02468889,  3.68, .57
NAME CANADA NET
DATA 3, .01246889,  5.22, .32
NAME WASH.  TROLL
DATA  3,.04537109,4.27,.57
NAME  WASH. PUGET NET
DATA  3, .01433827, 4.57, .39
NAME WASH. OCEAN SPORT
DATA  3,.00797127, 1, 12.34
NAME WASH. PUGET SPORT
DATA  3, .03288777, 1, 13.23
NAME OREGON TROLL
DATA  3,.00023534,4.27,.57
NAME OREGON SPORT
DATA  3,.00004167,1.,15.00
ESCAPE 2, .00175468, 1.,  .50,    0,  .20,   0
ESCAPE 3, .03880356, .5, 1.00, 1.40,  .40, .40
SIZETIME  13.69,8/1
NAME CANADA TROLL
DATA 3, .02468889,  3.59, .57
NAME CANADA NET
DATA 3, .01246889,  5.09, .32
NAME WASH.  TROLL
DATA  3,.07394302,4.16,.57
NAME  WASH. PUGET NET
DATA  3, .02336763, 4.46, .39
NAME WASH. OCEAN SPORT
DATA  3, .01299109, 1, 12.27
NAME WASH. PUGET SPORT
DATA  3, .05359348, 1, 13.14
NAME OREGON TROLL
DATA  3,.00023534,4.16,.57
NAME OREGON SPORT
DATA  3,.00004167,1.,14.87
ESCAPE 2, .00285967, 1.,  .49,    0,  .19,   0
ESCAPE 3, .06323967, .5,  .98, 1.38,  .39, .39
```

```
SIZETIME  5.2,8/1
NAME CANADA TROLL
DATA 3, .02468889,  3.72, .57
NAME CANADA NET
DATA 3, .01246889,  5.28, .32
NAME WASH.  TROLL
DATA  3,.15084965,4.21,.57
NAME  WASH. PUGET NET
DATA  3, .04767182, 4.63, .39
NAME WASH. OCEAN SPORT
DATA  3, .02650287, 1, 12.36
NAME WASH. PUGET SPORT
DATA  3, .10934516, 1, 13.26
NAME OREGON TROLL
DATA  3,.00023534,4.31,.51
NAME OREGON SPORT
DATA  3,.00004167,1.,15.04
ESCAPE 2, .00583396, 1.,  .50,    0,  .20,   0
ESCAPE 3, .12901396, .5, 1.00, 1.40,  .40, .40

*FISHERY CHINOOK
SIZES      200,50
TIMES      5/1,7/1
AGES       2,5
FISHERIES  7
SIZETIME  200,5/1
NAME CANADA TROLL
DATA 3, .00108090,  9.66,   .63
DATA 4, .00065185, 16.66,   .82
DATA 5, .00002559, 23.29,   .82
NAME CANADA NET
DATA 3, .00013171,  7.58,   .41
NAME CANADA SPORT
DATA 3, .00008096,  1.  , 19.
DATA 4, .00004883,  1.  , 26.
DATA 5, .00000192,  1.  , 32.
NAME WASH. TROLL
DATA  3,.00001057,9.18,.67
DATA  4,.00001577,16.19,.86
NAME WASH. PUGET NET
DATA  3,.00021005,13.2,.48
DATA  4,.00015673,19.9,.61
DATA  5,.00000860,26.7,.61
NAME WASH. OCEAN SPORT
DATA  3,.00008516,1.,19.80
DATA  4,.00004655,1.,28.99
NAME WASH. PUGET SPORT
DATA  2,.00003886,1.,14.90
DATA  3,.00015164,1.,23.00
DATA  4,.00009876,1.,29.60
DATA  5,.00001367,1.,36.30
ESCAPE 2, .00002034, 1.  , 1.55,    0,  .62,    0
ESCAPE 3, .00026268,  .70, 3.25, 5.65, 1.30, 1.30
ESCAPE 4, .00026299,  .44, 4.80, 7.20, 1.96, 1.96
ESCAPE 5, .00002034,  .23, 6.57, 8.97, 2.63, 2.63
SIZETIME   50,5/1
NAME CANADA TROLL
DATA 3, .00404228,  9.66,   .63
DATA 4, .00243775, 16.66,   .82
DATA 5, .00009571, 23.29,   .82
NAME CANADA NET
DATA 3, .00049257,  7.58,   .41
NAME CANADA SPORT
DATA 3, .00030278,  1.  , 19.
DATA 4, .00018260,  1.  , 26.
DATA 5, .00000716,  1.  , 32.
NAME WASH. TROLL
DATA  3,.00003953,9.18,.67
DATA  4,.00005898,16.19,.86
```

```
NAME WASH. PUGET NET
DATA  3,.00078554,13.2,.48
DATA  4,.00058611,19.9,.61
DATA  5,.00003217,26.7,.61
NAME WASH. OCEAN SPORT
DATA  3,.00031846,1.,19.80
DATA  4,.00017410,1.,28.99
NAME WASH. PUGET SPORT
DATA  2,.00014533,1.,14.90
DATA  3,.00056711,1.,23.00
DATA  4,.00036932,1.,29.60
DATA  5,.00005111,1.,36.30
ESCAPE 2, .00007607, 1.  , 1.55,    0,  .62,  .62
ESCAPE 3, .00098236,  .70, 3.25, 5.65, 1.30, 1.30
ESCAPE 4, .00098352,  .44, 4.80, 7.20, 1.96, 1.96
ESCAPE 5, .00007607,  .23, 6.57, 8.97, 2.63, 2.63
SIZETIME  200,7/1
NAME CANADA TROLL
DATA 3, .00244666,  9.66,    .63
DATA 4, .00147549, 16.66,    .82
DATA 5, .00005793, 23.29,    .82
NAME CANADA NET
DATA 3, .00029813,  7.58,    .41
NAME CANADA SPORT
DATA 3, .00018326,  1.  , 19.
DATA 4, .00011052,  1.  , 26.
DATA 5, .00000434,  1.  , 32.
NAME WASH. TROLL
DATA  3,.00002393,9.18,.67
DATA  4,.00003570,16.19,.86
NAME WASH. PUGET NET
DATA  3,.00047546,13.2,.48
DATA  4,.00035475,19.9,.61
DATA  5,.00001947,26.7,.61
NAME WASH. OCEAN SPORT
DATA  3,.00019276,1.,19.80
DATA  4,.00010538,1.,28.99
NAME WASH. PUGET SPORT
DATA  2,.00008797,1.,14.90
DATA  3,.00034325,1.,23.00
DATA  4,.00022354,1.,29.60
DATA  5,.00003093,1.,36.30
ESCAPE 2, .00004605, 1.  , 1.55,    0,  .62,  .62
ESCAPE 3, .00059460,  .70, 3.25, 5.65, 1.30, 1.30
ESCAPE 4, .00059530,  .44, 4.80, 7.20, 1.96, 1.96
ESCAPE 5, .00004605,  .23, 6.57, 8.97, 2.63, 2.63
SIZETIME   50,7/1
NAME CANADA TROLL
DATA 3, .00540804,  9.66,    .63
DATA 4, .00326139, 16.66,    .82
DATA 5, .00012805, 23.29,    .82
NAME CANADA NET
DATA 3, .00065899,  7.58,    .41
NAME CANADA SPORT
DATA 3, .00040508,  1.  , 19.
DATA 4, .00024429,  1.  , 26.
DATA 5, .00000958,  1.  , 32.
NAME WASH. TROLL
DATA  3,.00005289,9.18,.67
DATA  4,.00007891,16.19,.86
NAME WASH. PUGET NET
DATA  3,.00105095,13.2,.48
DATA  4,.00078413,19.9,.61
DATA  5,.00004304,26.7,.61
NAME WASH. OCEAN SPORT
DATA  3,.00042606,1.,19.80
DATA  4,.00023293,1.,28.99
NAME WASH. PUGET SPORT
DATA  2,.00019444,1.,14.20
DATA  3,.00075872,1.,23.00
DATA  4,.00049410,1.,29.60
DATA  5,.00006837,1.,36.30
ESCAPE 2, .00010178, 1.  , 1.55,    0,  .62,  .62
ESCAPE 3, .00131428,  .70, 3.25, 5.65, 1.30, 1.30
ESCAPE 4, .00131583,  .44, 4.80, 7.20, 1.96, 1.96
ESCAPE 5, .00010178,  .23, 6.57, 8.97, 2.63, 2.63
```

Appendix C

HATCH Output Example

HATCHERY PERFORMANCE---LOT SUMMARY

LOT-- COHO

HALF-MONTH PERIOD BEGINNING	SOURCE WATER TEMP.	POND WATER TEMP.	FISH IN HATCH. (X1000)	FISH RELSED (X1000)	POUNDS RELSED	WT. (FISH /LB)	DAILY RATN. (PC)	WEEKLY FEED (LBS)	FOOD CONV. FACTOR	WATER REQ. (GPM)	POND SPACE (GPM)	WATER AVAIL (GPM)	UNUSED WATER (GPM)	P.C. POND CAP.	P.C. HATCH CAP.
APRIL 1	47.0	47.0	4280			1107	3.10	910	1.28	1749	15120	15120	13371	11.6	11.6
APRIL 15	48.0	48.0	4254			809	3.07	1226	1.27	2089	15120	15120	13031	13.8	13.8
MAY 1	50.0	50.0	4235			591	3.86	2099	1.10	2852	15120	15120	12268	18.9	18.9
MAY 15	51.0	51.0	4222			386	3.81	3168	1.09	4135	15120	15120	10985	27.3	27.3
JUNE 1	52.0	52.0	4213			252	2.95	3742	1.22	5368	15120	15120	9752	35.5	35.5
JUNE 15	53.0	53.0	4206			184	2.91	5049	1.21	6642	15120	15120	8478	43.9	43.9
JULY 1	53.0	53.0	4199			135	2.38	5614	1.35	7917	15120	15120	7203	52.4	52.4
JULY 15	54.0	54.0	4191			106	2.37	7074	1.34	8754	15120	15120	6366	57.9	57.9
AUG. 1	54.0	54.0	4184			84	1.87	7090	1.64	8929	15120	15120	6191	59.1	59.1
AUG. 15	53.0	53.0	4180			72	1.79	7924	1.57	9340	15120	12230	2890	61.8	76.4
SEPT. 1	53.0	53.0	4175			61	1.33	6894	2.43	9340	15120	9340	0	61.8	100.0
SEPT. 15	51.0	51.0	4169			56	1.21	6819	2.22	8914	15120	9340	426	59.0	95.4
OCT. 1	50.0	50.0	4161			52	1.12	6782	2.26	8779	15120	9340	561	58.1	94.0
OCT. 15	48.0	48.0	4153			48	1.03	6701	2.08	8367	15120	9340	973	55.3	89.6
NOV. 1	46.0	46.0	4147			45	1.02	7150	1.76	8473	15120	9340	867	56.0	90.7
NOV. 15	46.0	46.0	4143			41	1.01	7691	1.74	8473	15120	9340	867	56.0	90.7
DEC. 1	44.0	44.0	4138			38	.65	5383	2.86	8472	15120	9340	868	56.0	90.7
DEC. 15	42.0	42.0	4131			37	.59	5008	2.57	8391	15120	12230	3839	55.5	68.6
JAN. 1	40.0	40.0	4127			36	.43	3808	4.13	8494	15120	14920	6426	56.2	56.2
JAN. 15	41.0	41.0	4125			35	.46	4102	4.38	8494	15120	14920	6426	56.2	56.2
FEB. 1	41.0	41.0	4123			34	.47	4315	3.70	8635	15120	14920	6285	57.1	57.1
FEB. 15	43.0	43.0	4121			34	.53	4909	4.13	8673	15120	14920	6247	57.4	57.4
MARCH 1	44.0	44.0	4119			33	.80	7533	1.87	8913	15120	14920	6007	58.9	58.9
MARCH 15	45.0	45.0	4117			31	.82	8246	1.93	9370	15120	14920	5550	62.0	62.0
APRIL 1	47.0	47.0	4114			29	2.13*	22769	1.53	10587	15120	13371	2784	70.0	70.0
APRIL 15				4110	170586	24									

** UNPLANNED RELEASE, * MAXIMUM RATION

EGGS TAKEN	4954014
FISH RELEASED	4109643
POUNDS RELEASED	170586
TOTAL FEED(LBS)	304015
CONVERSION FACTOR	1.82
FEED COST	$ 63843

HATCHERY PERFORMANCE---LOT SUMMARY

LOT-- CHINOOK

HALF-MONTH PERIOD BEGINNING	SOURCE WATER TEMP.	POND WATER TEMP.	FISH IN HATCH. (X1000)	FISH RELSED (X1000)	POUNDS RELSED	WT. (FISH /LB)	DAILY RATN. (PC)	WEEKLY FEED (LBS)	FOOD CONV. FACTOR	WATER REQ. (GPM)	POND SPACE (GPM)	WATER AVAIL (GPM)	UNUSED WATER (GPM)	P.C. POND CAP.	P.C. HATCH CAP.
MARCH 1	44.0	44.0	2702			864	3.16	752	1.19	1434	15120	6007	4572	9.5	9.5
MARCH 15	45.0	45.0	2695			614	3.16	1054	1.18	1941	15120	5550	3609	12.8	12.8
APRIL 1	47.0	47.0	2690			437	3.98	1864	1.15	2784	15120	2784	0	18.4	18.4
APRIL 15	48.0	48.0	2686			286	4.15	2963	1.19	3964	15120	13031	9068	26.2	26.2
MAY 1	50.0	50.0	2682			187	3.25	3539	1.15	5090	15120	12268	7178	33.7	33.7
MAY 15	51.0	51.0	2678			131	3.26	5067	1.15	6467	15120	10985	4518	42.8	42.8
JUNE 1				2673	29247	91									

EGGS TAKEN		3160086
FISH RELEASED		2673141
POUNDS RELEASED		29247
TOTAL FEED(LBS)		30477
CONVERSION FACTOR		1.17
FEED COST	$	6400

WATER USAGE REQUIREMENTS BY LOT

WATER REQUIREMENTS(G.P.M.)IN 1000S

THE LAST * IN EACH LINE INDICATES THE TOTAL WATER FLOW AVAILABLE

LEGEND: SYMBOL	LOT
A	AGE-0 COHO
1	CHINOOK
-	AGE-1 COHO

WATER POLLUTION REPORT

HALF-MONTH PERIOD BEGINNING	WATER FLOW (GPM)	WEEKLY FEED (LBS)	DAILY FEED (LBS)	DAILY DRY FEED	DRY FEED PER FLOW (LBS/GPM)	**AMMONIA** TOTAL LBS.	LBS/ GPM	****BOD**** TOTAL LBS.	LBS/ GPM	**NITRATE** TOTAL LBS.	LBS/ GPM	*OXY. TOTAL LBS.	USE* LBS/ GPM	*PHOSPHATE* TOTAL LBS.	LBS/ GPM	**SOLIDS** TOTAL LBS.	LBS/ GPM
JAN. 1	15120	3808	501	341	.023	16	.0011	170	.0113	44	.0029	125	.0083	3	.0002	150	.0099
JAN. 15	15120	4102	539	367	.024	17	.0011	183	.0121	47	.0031	135	.0089	3	.0002	162	.0107
FEB. 1	15120	4315	567	386	.026	18	.0012	193	.0128	49	.0033	142	.0094	3	.0002	170	.0113
FEB. 15	15120	4909	646	439	.029	21	.0014	219	.0145	56	.0037	161	.0107	3	.0002	194	.0128
MARCH 1	15120	8285	1090	741	.049	35	.0023	370	.0245	95	.0063	272	.0180	5	.0004	327	.0216
MARCH 15	15120	9300	1223	832	.055	39	.0026	416	.0275	106	.0070	306	.0202	6	.0004	367	.0243
APRIL 1	15120	25542	3359	2284	.151	107	.0071	1142	.0755	292	.0193	840	.0555	17	.0011	1008	.0666
APRIL 15	15120	4189	551	375	.025	18	.0012	187	.0124	48	.0032	138	.0091	3	.0002	165	.0109
MAY 1	15120	5638	741	504	.033	24	.0016	252	.0167	64	.0043	185	.0123	4	.0002	222	.0147
MAY 15	15120	8236	1083	736	.049	35	.0023	363	.0244	94	.0062	271	.0179	5	.0004	323	.0213
JUNE 1	15120	3742	492	335	.022	16	.0010	167	.0111	43	.0028	123	.0081	2	.0002	14[illegible]	.009[illegible]
JUNE 15	15120	5049	664	452	.030	21	.0014	226	.0149	58	.0038	166	.0110	3	.0002	199	.0132
JULY 1	15120	5614	738	502	.033	24	.0016	251	.0166	64	.0042	185	.0122	4	.0002	221	.0146
JULY 15	15120	7074	930	633	.042	30	.0020	316	.0209	81	.0054	233	.0154	5	.0003	279	.0185
AUG. 1	15120	7090	932	634	.042	30	.0020	317	.0210	81	.0054	233	.0154	5	.0003	280	.0185
AUG. 15	12230	7924	1042	709	.058	33	.0027	354	.0290	91	.0074	261	.0213	5	.0004	313	.0256
SEPT. 1	9340	6894	907	617	.066	29	.0031	308	.0330	79	.0084	227	.0243	5	.0005	272	.0291
SEPT. 15	9340	6319	897	610	.065	29	.0031	305	.0326	78	.0084	224	.0240	4	.0005	269	.0288
OCT. 1	9340	6782	892	606	.065	29	.0031	303	.0325	78	.0083	223	.0239	4	.0005	268	.0285
OCT. 15	9340	6701	881	599	.064	28	.0030	300	.0321	77	.0082	220	.0236	4	.0005	264	.0283
NOV. 1	9340	7150	940	639	.068	30	.0032	320	.0342	82	.0088	235	.0252	5	.0005	282	.0302
NOV. 15	9340	7691	1011	688	.074	32	.0035	344	.0368	88	.0094	253	.0271	5	.0005	303	.0325
DEC. 1	9340	5383	708	431	.052	23	.0024	241	.0258	62	.0066	177	.0189	4	.0004	212	.0227
DEC. 15	12230	5008	659	448	.037	21	.0017	224	.0183	57	.0047	165	.0135	3	.0003	198	.0162

********** FISHERY RESULTS FOR LOT-- COHO

CATCH STATISTICS-

FISHERY		AGE--2	AGE--3	SUB-TOTAL BY FISHERY
CANADA TROLL	NO. CAUGHT	0	80688	80688
	VALUE/FISH	0.00	2.63	
	CATCH VALUE	. 0	212219	212219
CANADA NET	NO. CAUGHT	0	40750	40750
	VALUE/FISH	0.00	2.09	
	CATCH VALUE	0	85337	85337
WASH. TROLL	NO. CAUGHT	0	18349	18349
	VALUE/FISH	0.00	3.05	
	CATCH VALUE	0	55915	55915
WASH. PUGET NET	NO. CAUGHT	0	36506	36506
	VALUE/FISH	0.00	2.13	
	CATCH VALUE	0	77613	77613
WASH. OCEAN SPORT	NO. CAUGHT	0	14386	14386
	VALUE/FISH	0.00	14.65	
	CATCH VALUE	0	210777	210777
WASH. PUGET SPORT	NO. CAUGHT	0	8268	8268
	VALUE/FISH	0.00	15.12	
	CATCH VALUE	0	125043	125043
OREGON TROLL	NO. CAUGHT	0	769	769
	VALUE/FISH	0.00	3.05	
	CATCH VALUE	0	2344	2344
OREGON SPORT	NO. CAUGHT	0	136	136
	VALUE/FISH	0.00	14.65	
	CATCH VALUE	0	1995	1995
SUB-TOTAL BY AGE	NO. CAUGHT	0	199852	
	CATCH VALUE	0	771242	

ESCAPEMENT STATISTICS-	AGE--2	AGE--3	TOTALS
NO. OF FISH	5964	63352	69316
MALE FRACTION	1.000	.500	.543
NO. OF FEMALES	0	31676	31676
EGGS/FEMALE	0	1885	
FEMALES SPAWNED	0	2629	2629
SPAWNED FISH VALUE	0	2126	2126
EXCESS FISH VALUE	5316	130794	136110

***** SUMMARY

NO. OF FISH RELEASED		4109643
NO. OF EGGS REQUIRED		4954014
NO. OF EGGS TAKEN		4955665
SURPLUS EGGS		54753595
TOTAL CATCH		199852
TOTAL ESCAPEMENT		69316
TOTAL CATCH VALUE	$	771242
TOTAL ESCAPEMENT VALUE	$	138236
TOTAL VALUE OF LOT	$	909477

********** FISHERY RESULTS FOR LOT-- CHINOOK

CATCH STATISTICS-

FISHERY		AGE--2	AGE--3	AGE--4	AGE--5	SUB-TOTAL BY FISHERY
CANADA TROLL	NO. CAUGHT	0	7850	4734	186	12770
	VALUE/FISH	0.00	5.11	10.82	14.27	
	CATCH VALUE	0	40112	51228	2653	93992
CANADA NET	NO. CAUGHT	0	957	0	0	957
	VALUE/FISH	0.00	2.61	0.00	0.00	
	CATCH VALUE	0	2496	0	0	2496
CANADA SPORT	NO. CAUGHT	0	588	355	14	957
	VALUE/FISH	0.00	15.95	20.59	23.91	
	CATCH VALUE	0	9380	7303	333	17016
WASH. TROLL	NO. CAUGHT	0	77	115	0	191
	VALUE/FISH	0.00	5.16	11.03	0.00	
	CATCH VALUE	0	396	1263	0	1660
WASH. PUGET NET	NO. CAUGHT	0	1526	1138	62	2726
	VALUE/FISH	0.00	5.32	9.62	12.17	
	CATCH VALUE	0	8116	10944	760	19820
WASH. OCEAN SPORT	NO. CAUGHT	0	618	338	0	957
	VALUE/FISH	0.00	16.62	22.96	0.00	
	CATCH VALUE	0	10282	7764	0	18045
WASH. PUGET SPORT	NO. CAUGHT	282	1101	717	99	2200
	VALUE/FISH	13.14	19.31	23.45	27.13	
	CATCH VALUE	3708	21268	16816	2692	44484
SUB-TOTAL BY AGE	NO. CAUGHT	282	12717	7397	362	
	CATCH VALUE	3708	92050	95318	6438	

ESCAPEMENT STATISTICS-	AGE--2	AGE--3	AGE--4	AGE--5	TOTALS
NO. OF FISH	147	1907	1910	147	4111
MALE FRACTION	1.000	.700	.440	.230	.573
NO. OF FEMALES	0	572	1070	113	1755
EGGS/FEMALE	0	4644	4644	4644	
FEMALES SPAWNED	0	0	568	113	681
SPAWNED FISH VALUE	0	0	1057	265	1323
EXCESS FISH VALUE	203	6356	5627	59	12245

***** SUMMARY

NO. OF FISH RELEASED		2673141
NO. OF EGGS REQUIRED		3160086
NO. OF EGGS TAKEN		3162564
SURPLUS EGGS		4987656
TOTAL CATCH		20757
TOTAL ESCAPEMENT		4111
TOTAL CATCH VALUE	$	197514
TOTAL ESCAPEMENT VALUE	$	13568
TOTAL VALUE OF LOT	$	211081

HATCHERY COST SUMMARY---

HATCHERY-- MINTER CREEK BASELINE

ANNUAL FIXED COSTS--

AMORTIZED CAPITAL COST	$	33333
AVERAGE INTEREST COST	$	38613
TOTAL FIXED COST	$	71946

ANNUAL OPERATING COSTS--

BASE CREW WAGES	$	35424
HELPER WAGES	$	28800
OVERHEAD COSTS	$	14129
MAINTENANCE COSTS	$	1200
SUPPLY COSTS	$	1800
PUMPING COSTS	$	0
TRUCKING COSTS	$	0
WATER REUSE COSTS	$	0
FEED COSTS	$	70243
TOTAL OPERATING COST	$	151597

TOTAL ANNUAL HATCHERY COSTS $ 223543

TOTAL ANNUAL FISHERY VALUE $ 1120559

BENEFIT/COST RATIO-- 5.01

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The HATCH model is an automated system for analyzing the physical, biological and economic factors of fish hatchery operation and for computing optimal hatchery management policies.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Benefit/cost; Fish Hatchery Analysis; Fish Hatchery Operation; Fish Hatchery Management; Mathematical Model.

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